TB6585FG/AFTG
Usage Considerations

Summary

TB6585FG/AFTG is a three-phase full-wave motor driver with sine-wave control.

Contents

1. Power supply voltage and output current

Characteristic	Symbol	Operating voltage range	Unit
Power supply voltage	V_M	4.5 to 42	V
Output current	I_{OUT}	Up to 1.8	A

2. Control inputs (RES, CW/CCW, V_{SP}, LA, and ML)

1) Input method

The RES, CW/CCW, LA, and ML input terminals should be open or low, until turning on VM.

2) V_{SP} input

V_{SP} input voltage range is zero to Vrefout (V). Voltage can be applied regardless of VM condition. However, the operation may become unstable if VM is applied after V_{SP} has been applied. So, please evaluate the operation enough before using.

3. Oscillation circuit

1) Operating range

Characteristic	Condition	Operating voltage range	Unit
Carrier frequency	OSC/C = 150 pF, OSC/R = 16 kΩ	18 to 22	kHz

2) Connection

Pleas place the oscillation circuit as close to the IC terminal as possible and connect the oscillator's GND as close to the IC's GND terminal as possible.

3) Calculation formula

Typical oscillation frequency can be calculated by the equations below.

$$\text{Fosc} = 1/\{(2\times \text{Vth}\times \text{C}/\text{I})+\text{Tdelay}\} \quad \cdots\cdots\cdot \quad \text{I} = \text{Vi} \times \text{G/R}$$
$$= 1/\{2 \times \text{Vth} \times \text{C}/(\text{Vi} \times \text{G/R}) + \text{Tdelay}\}$$

C = Exterior capacitor (150 pF)
R = Exterior resistor (16 kΩ)
Vth = Triangle-wave slesh voltage (Design value: 0.4 V)
Vi = Current switch reference voltage (Design value: 1 V)
G = Constant current amp rate (Design value: 13)
Tdelay = Circuit delay (50 nsec)

Carrier frequency is determined by the equation below.
Carrier frequency = Fosc/252

It is recommended to set OSC/C and OSC/R by adopting the set values in the table of (1). Please judge the applied value after evaluating the mounting variability because there is a possibility that the oscillation frequency changes depending on the mounting condition. Shipping test is carried by applying the above setting constant number. So, when other setting constant number is adopted, please judge the result by yourself. The range of the oscillation frequency should be set from 4 to 6 MHz

4. Motor lock detection

When the operation mode is not properly switched as configured from 120° commutation mode of startup operation to 180° commutation mode, the motor is deemed to be locked and output transistors are turned off. The restart operation can be selected from the automatic restart, the power cycling, or the back on V_{SP}. In case of the restart operation by the back on V_{SP}, V_{SP} must be kept below 1 V (typ.).

Capacitor connecting terminal of TR terminal
The terms of the motor-lock detection and the output-off can be adjusted by the external capacitor (C_1) of TR terminal. (Both terms are set to be the same.) The value of 180 pF is recommended for C1. Setting range is from 100 pF to 390 pF. Please apply these values after evaluating enough.

Term setting $T = \frac{C_1 \times V_{th}}{I} \times 1024(s)$ $I = 0.72\ \mu A$, $V_{th} = 2\ V$

Example: When C_1 = 180 pF, T ≈ 500 ms (typ.).

<Automatic restart (ML = High)>
When the hall signal frequency is kept below 2.5 Hz for at least 500 ms (typ.), the TB6585FG/AFTG becomes active and inactive periodically every 500 ms (typ.). The protection is disabled when the hall signal frequency reaches 2.5 Hz and the operation mode is switched to 180° commutation mode.

Note) When anti-lock protection is not used, connect the TR terminal to GND. Anti-lock capability is invalid regardless of ML.

5. Hall signal input

Please use this function within the input voltage range of the same phase.
The operation as a hall IC, where voltage range is 0 to 5 V, is invalid because the input voltage range of the same phase (V_{CMRH}) is 1.5 V to 3.5 V.

6. Current limit input terminal

When voltage of 0.5 V (typ.) or more is applied to RS terminal, driving outputs (U, V, and W) are turned off.
In case IR line has a noise, please connect low pass filter between the capacitor and the resistor. Cut-off frequency should be set enough high value because driving output operates with carrier frequency of 20 kHz.
If it has a noise problem though filter (200 kΩ/5 pF) is incorporated in RS terminal, please add further external filter.

7. Temperature rise

Temperature of the TB6585FG/AFTG may exceeds the maximum rating (Tj = 150℃) depending on the usage condition because it incorporates the driver. So, please design the device not to exceed the Tj of 150℃. Though it incorporates over-heat protection to protect the IC from the abnormal states, it cannot protect all functions because it works under the condition of over rating.

Calculating of Tj (example)
Conditions: Board: Saturated heat resistance = 39℃/W, Ambient temperature = 85℃ (max)
Pd (max): Maximum of power consumption of IC
IM, output Ron: Maximum values

ON resistance of output: Ron (H + L)	
Typ	Max
0.7	1.0

In case the motor steady current is 0.8A (rms),

Pd (max) = VM × IM + [Ron (H + L) Max/2] × Iout × Iout × 3

= 24 × 0.014 + 1.0/2 × 0.8 × 0.8 × 3 = 1.3 (W)

Junction temperature is calculated below,
Tjmax = Ta(max) + rth × Pd = 85℃ + 39 × 1.3 = 136℃
When the board (Rth (j-a) = 39℃/W) is used, the limit of actual motor current is around 0.8 A.
(For your reference: Measured on a board (140 mm × 70 mm × 1.6 mm, Cu 50 %: 39 °C/W))

8. Setting of auto lead angle part

Position of lead angle can be changed corresponding to the motor current (shunt current). Changing amplitude should be determined by testing with an actual motor because it depends on the used motor.

Step 1) Find the most appropriate LA voltage. Please drive the motor with required frequency, apply external voltage of 0 to 4.4 V to LA terminal, and confirm the current waveform or the current efficiency.
Most efficient LA voltage is recognized when the smallest motor current flows at the same frequency.

Step 2) Increase the value of shunt resistance voltage convertor by external resistor of Gin and Gout terminals in order to set the LA voltage which is introduced in “Step 1”.

Step 3) Drive the motor and confirm that the LA voltage equals to the value which is determined in “Step 1”.

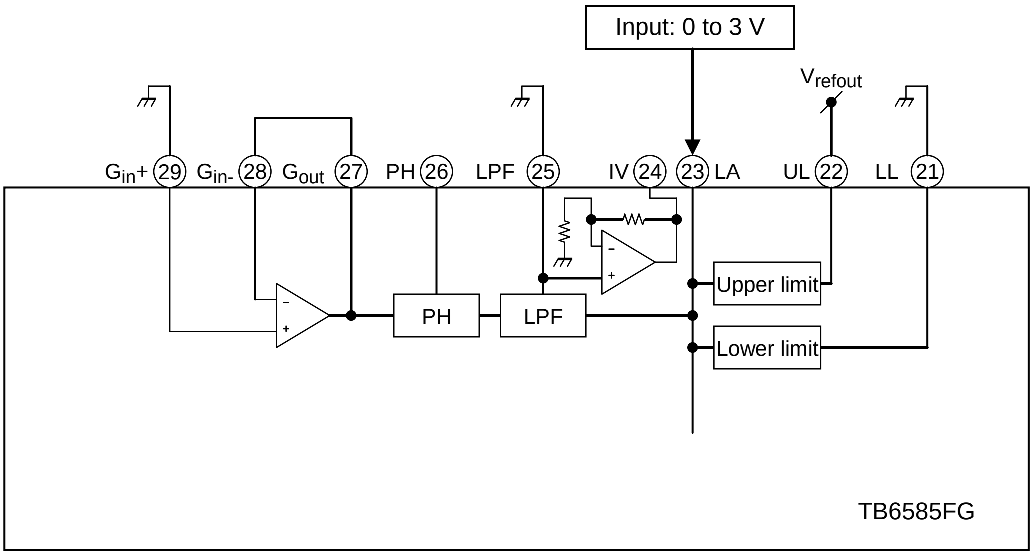
Remarks 1) PH terminal: 100 kΩ/0.1μF (Recommended value)
LPF terminal: 0.1μF (Recommended value)
Gain setting amplifier: Set with the resistor of 10 kΩ/100 kΩ.
Setting range: About 8 times to 20 times

In above experiment, the motor operation may be unstable when more or less than a certain voltage is applied to LA terminal. To avoid this unstable operation, please fix the voltage of UL and LL terminals
For example, when voltage of UL is set 2 V and that of LL is 1 V, the range of lead angle (LA voltage) is 1 V to 2 V.

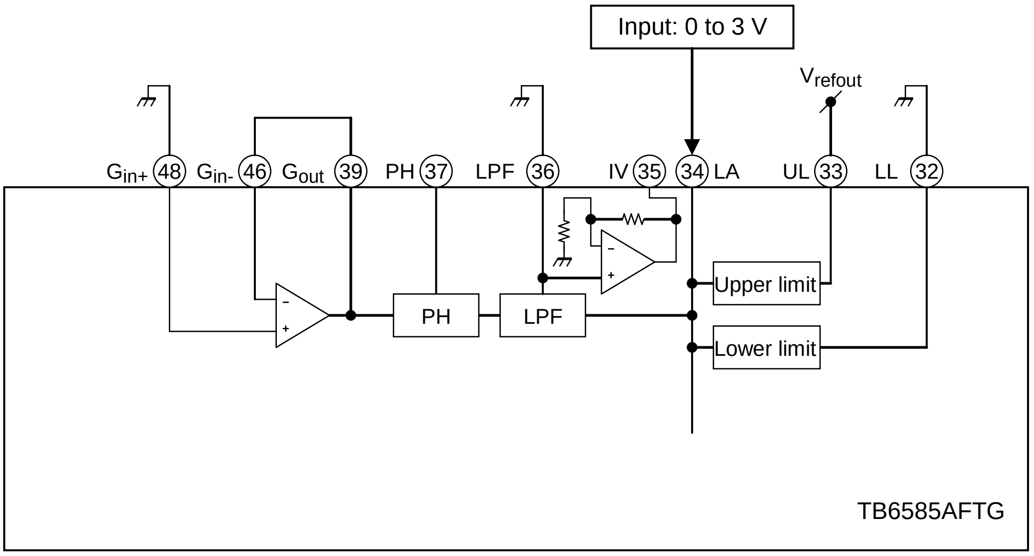
Remarks 2) When the auto lead angle function is not used, please design the circuit layout as follows in dealing with the terminal

Diagram Layout: without auto lead angle function

TB6585FG



TB6585AFTG



Notes on Contents

1. Block Diagrams

Some of the functional blocks, circuits, or constants in the block diagram may be omitted or simplified for explanatory purposes.

2. Equivalent Circuits

The equivalent circuit diagrams may be simplified or some parts of them may be omitted for explanatory purposes.

3. Timing Charts

Timing charts may be simplified for explanatory purposes.

4. Application Circuits

The application circuits shown in this document are provided for reference purposes only. Thorough evaluation is required, especially at the mass production design stage.

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5. Test Circuits

Components in the test circuits are used only to obtain and confirm the device characteristics. These components and circuits are not guaranteed to prevent malfunction or failure from occurring in the application equipment.

IC Usage Considerations

Notes on handling of ICs

(1) The absolute maximum ratings of a semiconductor device are a set of ratings that must not be exceeded, even for a moment. Do not exceed any of these ratings.
Exceeding the rating(s) may cause the device breakdown, damage or deterioration, and may result injury by explosion or combustion.

(2) Use an appropriate power supply fuse to ensure that a large current does not continuously flow in case of over current and/or IC failure. The IC will fully break down when used under conditions that exceed its absolute maximum ratings, when the wiring is routed improperly or when an abnormal pulse noise occurs from the wiring or load, causing a large current to continuously flow and the breakdown can lead smoke or ignition. To minimize the effects of the flow of a large current in case of breakdown, appropriate settings, such as fuse capacity, fusing time and insertion circuit location, are required.

(3) If your design includes an inductive load such as a motor coil, incorporate a protection circuit into the design to prevent device malfunction or breakdown caused by the current resulting from the inrush current at power ON or the negative current resulting from the back electromotive force at power OFF. IC breakdown may cause injury, smoke or ignition.
Use a stable power supply with ICs with built-in protection functions. If the power supply is unstable, the protection function may not operate, causing IC breakdown. IC breakdown may cause injury, smoke or ignition.

(4) Do not insert devices in the wrong orientation or incorrectly.
Make sure that the positive and negative terminals of power supplies are connected properly.
Otherwise, the current or power consumption may exceed the absolute maximum rating, and exceeding the rating(s) may cause the device breakdown, damage or deterioration, and may result injury by explosion or combustion.
In addition, do not use any device that is applied the current with inserting in the wrong orientation or incorrectly even just one time.

Points to Remember on Handling of ICs

(1) Over current protection circuit

Over current protection circuits (referred to as current limiter circuits) do not necessarily protect ICs under all circumstances. If the Over current protection circuits operate against the over current, clear the over current status immediately.

Depending on the method of use and usage conditions, such as exceeding absolute maximum ratings can cause the over current protection circuit to not operate properly or IC breakdown before operation. In addition, depending on the method of use and usage conditions, if over current continues to flow for a long time after operation, the IC may generate heat resulting in breakdown.

(2) Thermal shutdown circuit

Thermal shutdown circuits do not necessarily protect ICs under all circumstances. If the thermal shutdown circuits operate against the over temperature, clear the heat generation status immediately.

Depending on the method of use and usage conditions, such as exceeding absolute maximum ratings can cause the thermal shutdown circuit to not operate properly or IC breakdown before operation.

(3) Heat radiation design

In using an IC with large current flow such as power amp, regulator or driver, please design the device so that heat is appropriately radiated, not to exceed the specified junction temperature (TJ) at any time and condition. These ICs generate heat even during normal use. An inadequate IC heat radiation design can lead to decrease in IC life, deterioration of IC characteristics or IC breakdown. In addition, please design the device taking into considerate the effect of IC heat radiation with peripheral components.

(1) Back-EMF

When a motor rotates in the reverse direction, stops or slows down abruptly, a current flow back to the motor's power supply due to the effect of back-EMF. If the current sink capability of the power supply is small, the device's motor power supply and output pins might be exposed to conditions beyond absolute maximum ratings. To avoid this problem, take the effect of back-EMF into consideration in system design.

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